



# UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE  
United States Patent and Trademark Office  
Address: COMMISSIONER FOR PATENTS  
P.O. Box 1450  
Alexandria, Virginia 22313-1450  
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/589,794	08/17/2006	Sven Woop	119835-163886	8682

60172 7590 02/15/2011  
SCHWABE, WILLIAMSON & WYATT, P.C.  
1420 FIFTH AVENUE, SUITE 3400  
SEATTLE, WA 98101-4010

EXAMINER
----------

HOANG, PHI

ART UNIT	PAPER NUMBER
----------	--------------

2628

MAIL DATE	DELIVERY MODE
-----------	---------------

02/15/2011

PAPER

**Please find below and/or attached an Office communication concerning this application or proceeding.**

The time period for reply, if any, is set in the attached communication.

<b>Office Action Summary</b>	<b>Application No.</b> 10/589,794	<b>Applicant(s)</b> WOOP ET AL.	
	<b>Examiner</b> PHI HOANG	<b>Art Unit</b> 2628	

**-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --**

### Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

### Status

- 1) ☒ Responsive to communication(s) filed on 03 December 2010.
- 2a) ☐ This action is **FINAL**.                      2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

### Disposition of Claims

- 4) ☒ Claim(s) 17-39 is/are pending in the application.
- 4a) Of the above claim(s) \_\_\_\_\_ is/are withdrawn from consideration.
- 5) ☐ Claim(s) \_\_\_\_\_ is/are allowed.
- 6) ☒ Claim(s) 17-39 is/are rejected.
- 7) ☐ Claim(s) \_\_\_\_\_ is/are objected to.
- 8) ☐ Claim(s) \_\_\_\_\_ are subject to restriction and/or election requirement.

### Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on \_\_\_\_\_ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.  
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).  
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

### Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All    b) ☐ Some \*    c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. \_\_\_\_\_.
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

\* See the attached detailed Office action for a list of the certified copies not received.

### Attachment(s)

- |  |   |
|--|---|
| 1) <input checked="" type="checkbox"/> Notice of References Cited (PTO-892)            | 4) <input type="checkbox"/> Interview Summary (PTO-413)           |
| 2) <input type="checkbox"/> Notice of Draftperson's Patent Drawing Review (PTO-948)    | Paper No(s)/Mail Date. _____                                      |
| 3) <input checked="" type="checkbox"/> Information Disclosure Statement(s) (PTO/SB/08) | 5) <input type="checkbox"/> Notice of Informal Patent Application |
| Paper No(s)/Mail Date <u>27 January 2011</u> .   | 6) <input type="checkbox"/> Other: _____                          |

## **DETAILED ACTION**

### ***Response to Arguments***

1. Applicant's arguments, see pages 11-16, filed 03 December 2010, with respect to the rejection(s) of claim(s) 17-39 under 35 U.S.C. 103 have been fully considered and are persuasive. Therefore, the rejection has been withdrawn. However, upon further consideration, a new ground(s) of rejection is made in view of Munshi (US 2003/0001842 A1).

### ***Claim Rejections - 35 USC § 103***

2. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

3. Claims 17-21, 24-29, and 32-36 are rejected under 35 U.S.C. 103(a) as being unpatentable over Wrigley (US 5,933,146) in view of Munshi (US 2003/0001842 A1).

4. Regarding claim 17, Wrigley discloses a method for rendering three-dimensional scenes on a display of a computing device, the method comprising: rendering the three dimensional scenes, by the computing device, via ray-tracing; (Figure 1 and column 4, lines 47-58)

establishing, by the computing device, a ray-tracing acceleration structure having

a plurality of objects; (Figure 6 and column 6, lines 65-67)

traversing, by the computing device, a ray through the acceleration structure until an object of intersection with the ray is identified; (Column 6, lines 35-64)

performing a first intersection computation between the object of intersection and the ray; (Column 6, lines 53-61)

Wrigley does not clearly disclose storing, by the computing device, the object of intersection in a list of objects that have been intersected by the ray; and after the object of intersection is stored in the list; searching the list, by the computer device, for the object of intersection, and preventing, by the computing device, further performing of intersection computations between the object of intersection and the ray after performing the first intersection computation.

Munshi discloses storing, by the computing device, the object of intersection in a list of objects that have been intersected by the ray; (Figure 4)

and after the object of intersection is stored in the list; searching the list, by the computer device, for the object of intersection, (Paragraph 0030, lines 1-7)

and preventing, by the computing device, further performing of intersection computations between the object of intersection and the ray after performing the first intersection computation (Paragraph 0030, lines 7-23).

Therefore, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to modify Wrigley to monitor previous intersections of rays with objects as disclosed by Munshi because unnecessary calculations resulting from intersections by the ray are ignored (Paragraph 0027, lines 15-23).

5. Regarding claim 18, Wrigley discloses determining, by the computing device, whether an affirmative decision is possible as to whether a triangle within the ray-tracing acceleration structure overlaps a node of the acceleration structure, the decision being based at least in part on comparisons of the vertices of the triangle with the vertices of the node; and when the affirmative decision is not possible, deciding, by the computing device, by making a conservative decision as to whether the triangle overlaps the node (Column 18, line 64 – column 19, line 40).

6. Regarding claim 19, Wrigley discloses computing, by the computing device, a three dimensional ray space occupied by a ray according to the ray's increasing distance from a virtual source; (Column 9, lines 9-12)

traversing, by the computing device, the ray space; (Column 9, lines 12-14)  
and processing, by the computing device, selected objects identified within the ray space (Column 9, lines 14-28).

7. Regarding claim 20, Wrigley discloses the ray space is a selected one of a cone or a pyramid, and the method further comprises processing, by the computing device, objects within the ray space, and ordering the objects according to the objects' virtual distances from the virtual source of the ray (Figure 2).

8. Regarding claim 21, Wrigley in view of Munshi discloses the ray-tracing acceleration structure further comprises at least one acceleration structure node, with each node being associated with a region of node space, and the method further comprises (Wrigley, Figure 6): storing, by the computing device, simplified geometry

Art Unit: 2628

data associated with respective acceleration structure nodes, the respective simplified geometry data omitting one or more triangles from geometry data for the node (Wrigley, Figure 6 and column 6, lines 35-47, envelopes) which omits one or more triangles from geometry data for the node (Munshi, paragraph 0030);

and computing, by the computing device, a ray-object intersection, using the simplified geometry data to compute the ray-object intersection when the ray space overlaps a majority of the node space (Wrigley, Column 6, lines 48-64).

9. Regarding claim 24, Wrigley discloses an apparatus for rendering three-dimensional scenes, the apparatus comprising: a processor; (Figure 9, element 74)

a tangible computer-accessible storage medium operatively coupled to the processor; (Figure 9, element 70)

a ray-tracing acceleration structure stored in the storage medium, the acceleration structure having object data for a plurality of objects; (Figure 6 and column 6, lines 65-67)

Wrigley does not clearly disclose a ray-casting module operatively configured to traverse rays through the acceleration structure and return ray-object intersection data, the ray-casting module comprising a decision unit operatively configured such that, when ray-object intersection data has been computed for a given ray and a given object, the decision unit record that the given ray has intersected the given object and prevents additional ray-object intersection computations from being carried out for the given ray and the given object.

Munshi discloses a ray-casting module operatively configured to traverse rays

Art Unit: 2628

through the acceleration structure (Figure 4) and return ray-object intersection data, the ray-casting module comprising a decision unit operatively configured such that, when ray-object intersection data has been computed for a given ray and a given object, the decision unit record that the given ray has intersected the given object (Paragraph 0030, lines 1-7) and prevents additional ray-object intersection computations from being carried out for the given ray and the given object (Paragraph 0030, lines 7-23)

Therefore, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to modify Wrigley to monitor previous intersections of rays with objects as disclosed by Munshi because unnecessary calculations resulting from intersections by the ray are ignored (Paragraph 0027, lines 15-23).

10. Regarding claim 25, Wrigley discloses determining if an affirmative decision is possible as to whether a triangle within the ray-tracing acceleration structure overlaps a node of the acceleration structure, the decision being based at least in part on comparisons of the vertices of the triangle with the vertices of the node; and if the affirmative decision is possible, store the affirmative decision as part of establishing the acceleration structure (Column 18, line 64 – column 19, line 32).

11. Regarding claim 26, Wrigley discloses if the affirmative decision is not possible, a conservative decision as to whether the triangle overlaps the node and store the conservative decision as part of establishing the acceleration structure (Column 19, lines 33-40).

12. Regarding claim 27, Wrigley discloses the ray-casting module further comprises a traversal unit, the traversal unit operatively configured to: compute a three dimensional ray space occupied by a ray according to the ray's increasing distance from a virtual source; (Column 9, lines 9-12)

and traverse the ray space through the acceleration structure from the virtual source of the ray through an increasing virtual distance from the virtual source of the ray. (Column 9, lines 12-14)

13. Regarding claim 28, Wrigley discloses the ray space traversed is a selected one of a cone or a pyramid (Figure 2).

14. Regarding claim 29, Wrigley in view of Munshi discloses at least one acceleration structure node, each node being associated with a region of node space; (Wrigley, Figure 6)

and wherein the ray casting module is further configured to store simplified geometry data associated with each acceleration structure node; (Wrigley, Figure 6 and column 6, lines 35-47, envelopes) which omits one or more triangles from geometry data for the node (Munshi, paragraph 0030);

and, when the ray space overlaps a majority of the node space, compute ray-object intersection using the simplified geometry data (Wrigley, Column 6, lines 48-64).

15. Regarding claim 32, Wrigley discloses an article of manufacture comprising a tangible, non-transitory computer-accessible storage medium (Figure 9, element 70) for digitally storing a plurality of programming instructions designed to program an



Art Unit: 2628

apparatus to render three-dimensional scenes via ray-tracing, wherein the programming instructions, if executed by the apparatus, enable the apparatus to: establish ray tracing acceleration structures having a plurality of objects (Figure 6 and column 6, lines 35-67).

Wrigley does not clearly disclose for a given ray, and for an object for which an intersection computation has been performed with the given ray; record that the intersection computation has been performed for the given ray and the object; and prevent further performing of intersection computations between the objects and the given ray.

Munshi discloses for a given ray, and for an object for which an intersection computation has been performed with the given ray: record that the intersection computation has been performed for the given ray and the object; (Figure 4 and paragraph 0030, lines 1-7)

and prevent further performing of intersection computations between the objects and the given ray (Paragraph 0030, lines 7-23).

Therefore, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to modify Wrigley to monitor previous intersections of rays with objects as disclosed by Munshi because unnecessary calculations resulting from intersections by the ray are ignored (Paragraph 0027, lines 15-23).

16. Regarding claim 33, Wrigley discloses determining if an affirmative decision is possible as to whether a triangle within the ray-tracing acceleration structure overlaps a node of the acceleration structure, the decision being based at least in part on

Art Unit: 2628

comparisons of the vertices of the triangle with the vertices of the node; and if the affirmative decision is not possible, decide by making a conservative decision as to whether the triangle overlaps the node (Column 18, line 64 – column 19, line 40).

17. Regarding claim 34, Wrigley discloses computing a three dimensional ray space occupied by the given ray according to the ray's increasing distance from a virtual source; (Column 9, lines 9-12)

traverse the ray space through the acceleration structure; (Column 9, lines 12-14)

and process selected objects identified within the ray space (Column 9, lines 14-28).

18. Regarding claim 35, Wrigley discloses the ray space traversed by the ray is a selected one of a cone or a pyramid, and the programming instructions, if executed, further enable the apparatus to process the selected objects within the ray space, and order the selected objects according to the selected objects' virtual distances from the virtual source of the ray (Figure 2).

19. Regarding claim 36, Wrigley in view of Munshi discloses storing simplified geometry data associated with each acceleration structure node (Wrigley, Figure 6 and column 6, lines 35-47, envelopes) which omits one or more triangles from geometry data for the node (Munshi, paragraph 0030);

and when the ray space overlaps a majority of the node space, compute ray-object intersection, using the simplified geometry data (Wrigley, Column 6, lines 48-64).

20. Claims 22, 23, 37, and 38 are rejected under 35 U.S.C. 103(a) as being unpatentable over Wrigley (US 5,933,146) in view of Munshi (US 2003/0001842 A1) in view of Lathrop (US 6,597,359 B1)..

21. Regarding claim 22, Wrigley in view of Munshi discloses all limitations as discussed in claim 17.

Wrigley in view of Munshi does not clearly disclose subdividing, by the computing device, the plurality of objects into an n-level hierarchy of objects and sub-objects; classifying, by the computing device, the objects as primitive or non-primitive; traversing a ray through the acceleration structure until an intersected object is identified; and after traversing the ray if the identified object is not a primitive object, storing, by the computing device, affine transformation data which transforms the object and ray into a coordinate system locally associated with the identified object, and traversing the local coordinate system and storing affine transformation data, recursively, until the ray intersects with a primitive object; and if the identified object is a primitive object, storing by the computing device, transformation data which transforms the primitive object and ray into a normalized object space locally associated with the identified object, intersecting the transformed ray with the transformed identified object, and storing, by the computing device, ray-object intersection data.

Lathrop discloses subdividing, by the computing device, the plurality of objects into an n-level hierarchy of objects and sub-objects; (Figure 5 and column 7, lines 39-62)

classifying, by the computing device, the objects as primitive or non-primitive;

Art Unit: 2628

(Column 9, lines 31-34)

traversing a ray through the acceleration structure until an intersected object is identified; (Column 9, lines 9-18)

and after traversing the ray if the identified object is not a primitive object, storing, by the computing device, affine transformation data which transforms the object and ray into a coordinate system locally associated with the identified object, and traversing the local coordinate system and storing affine transformation data, recursively, until the ray intersects with a primitive object; (Column 10, lines 49-67)

and if the identified object is a primitive object, storing by the computing device, transformation data which transforms the primitive object and ray into a normalized object space locally associated with the identified object, intersecting the transformed ray with the transformed identified object, and storing, by the computing device, ray-object intersection data (Column 11, lines 1-19).

Therefore, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to modify Wrigley in view of Munshi to divide a scene with objects at various levels as disclosed by Lathrop because objects can be quickly and efficiently located for ray intersection.

22. Regarding claim 23, Wrigley in view of Munshi discloses all limitations as discussed in claim 17.

Wrigley in view of Munshi does not clearly disclose subdividing, by the computing device, the plurality of objects into an n-level hierarchy of objects and sub-objects; recursively instantiating, by the computing device, a plurality of sub-objects, the sub-

objects having a similar geometry; and building, by the computing device, a next level object by, at least in part, using the plurality of instantiated sub-objects with similar geometry.

Lathrop discloses subdividing, by the computing device, the plurality of objects into an n-level hierarchy of objects and sub-objects; (Figure 5 and column 7, lines 39-62)

recursively instantiating, by the computing device, a plurality of sub-objects, the sub-objects having a similar geometry; (Column 8, lines 32-49)

and building, by the computing device, a next level object by, at least in part, using the plurality of instantiated sub-objects with similar geometry (Column 8, line 64 – column 9, line 8).

Therefore, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to modify Wrigley in view of Munshi to divide a scene with objects at various levels as disclosed by Lathrop because objects can be quickly and efficiently located for ray intersection.

23. Regarding claim 37, Wrigley in view of Munshi discloses all limitations as discussed in claim 32.

Wrigley in view of Munshi does not clearly disclose subdividing the plurality of objects into an n-level hierarchy of objects and sub- objects; classifying the objects as primitive or non-primitive; traversing the given ray through the acceleration structure until an intersected object is identified, if the identified object is not a primitive object, store affine transformation data which transforms the identified object and ray into a

Art Unit: 2628

coordinate system locally associated with the identified object, and traverse the transformed ray through the local coordinate system and store affine transformation data, recursively, until the ray intersects with a primitive object; and if the identified object is a primitive object, store transformation data which transforms the primitive object and ray into a normalized object space locally associated with the identified object, intersect the transformed ray with the transformed identified object, and store ray-object intersection data.

Lathrop discloses subdividing the plurality of objects into an n-level hierarchy of objects and sub- objects; (Figure 5 and column 7, lines 39-62)

classifying the objects as primitive or non-primitive; traversing the given ray through the acceleration structure until an intersected object is identified, if the identified object is not a primitive object, store affine transformation data which transforms the identified object and ray into a coordinate system locally associated with the identified object, and traverse the transformed ray through the local coordinate system and store affine transformation data, recursively, until the ray intersects with a primitive object; (Column 10, lines 49-67)

and if the identified object is a primitive object, store transformation data which transforms the primitive object and ray into a normalized object space locally associated with the identified object, intersect the transformed ray with the transformed identified object, and store ray-object intersection data (Column 11, lines 1-19).

Therefore, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to modify Wrigley in view of Munshi to divide a scene

with objects at various levels as disclosed by Lathrop because objects can be quickly and efficiently located for ray intersection.

24. Regarding claim 38, Wrigley in view of Munshi discloses all limitations as discussed in claim 32.

Wrigley in view of Munshi does not clearly disclose subdividing the plurality of objects into an n-level hierarchy of objects and sub- objects; recursively instantiating a plurality of sub-objects, the sub-objects having a similar geometry; and building a next level object by, at least in part, using the plurality of instantiated sub-objects with similar geometry.

Lathrop discloses subdividing the plurality of objects into an n-level hierarchy of objects and sub- objects; (Figure 5 and column 7, lines 39-62)

recursively instantiating a plurality of sub-objects, the sub-objects having a similar geometry; (Column 8, lines 32-49)

and building a next level object by, at least in part, using the plurality of instantiated sub-objects with similar geometry (Column 8, line 64 – column 9, line 8).

Therefore, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to modify Wrigley in view of Munshi to divide a scene with objects at various levels as disclosed by Lathrop because objects can be quickly and efficiently located for ray intersection.

Art Unit: 2628

25. Claim 30 is rejected under 35 U.S.C. 103(a) as being unpatentable over Wrigley (US 5,933,146) in view of Munshi (US 2003/0001842 A1) and further in Lee et al. (US 2004/0233222).

26. Regarding claim 30, Wrigley in view of Munshi discloses all limitations as discussed in claim 24.

Munshi further discloses a ray casting unit (Figure 2, element 204).

Wrigley in view of Munshi does not clearly disclose a matrix unit; a transformation unit; wherein the matrix unit is operatively configured to send affine transformation matrices of object data to the transformation unit, each affine transformation matrix being a selected one of an object-space transformation matrix and a normalized space transformation matrix, and the transformation unit is further operatively configured to receive a ray from the ray casting unit and transform the ray into the object's affine transformation matrix's coordinate system.

Lee discloses performing affine transformations using an affine transformation matrix (Paragraphs 0046 and 0047).

Therefore, it would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Wrigley in view of Munshi to performing a transformation using an affine matrix as disclosed by Lee because a simpler coordinate system can be obtained while preserving collinearity after the transformation.



Art Unit: 2628

27. Claims 31 and 39 are rejected under 35 U.S.C. 103(a) as being unpatentable over Wrigley (US 5,933,146) in view of Munshi (US 2003/0001842 A1) in Lee et al. (US 2004/0233222) and further in view of Lathrop (US 6,597,359 B1).

28. Regarding claim 31, Wrigley in view of Munshi and further in view of Lee discloses all limitations as discussed in claim 30.

Wrigley in view of Munshi and further in view of Lee does not clearly disclose an acceleration structure computation unit operatively configured to subdivide the plurality of objects into an n-level hierarchy of objects and sub-objects and store data classifying the objects as primitive or non-primitive; a traversal unit operatively configured to traverse a ray through the acceleration structure until a potential ray-object intersection is identified; and an intersection computation unit; wherein, the transformation unit is operatively configured to send the object's affine transformation matrix data and the transformed ray data to the transversal unit for recursive processing until the ray intersects with a primitive object, if the object identified by the traversal unit is not a primitive object; and wherein, the transformation unit is operatively configured to send the object's affine transformation matrix data and the transformed ray data to the intersection computation unit, if the object identified by the traversal unit is a primitive object.

Lathrop discloses an acceleration structure computation unit operatively configured to subdivide the plurality of objects into an n-level hierarchy of objects and sub-objects and store data classifying the objects as primitive or non-primitive; (Figure 5 and column 7, lines 39-62)

a traversal unit operatively configured to traverse a ray through the acceleration structure until a potential ray-object intersection is identified; (Column 12, lines 60 – column 13, line 3)

and an intersection computation unit; (Column 13, lines 3-10)

wherein, the transformation unit is operatively configured to send the object's affine transformation matrix data and the transformed ray data to the transversal unit for recursive processing until the ray intersects with a primitive object, if the object identified by the traversal unit is not a primitive object; (Column 10, lines 49-67)

and wherein, the transformation unit is operatively configured to send the object's affine transformation matrix data and the transformed ray data to the intersection computation unit, if the object identified by the traversal unit is a primitive object (Column 11, lines 1-19).

Therefore, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to modify Wrigley in view of Munshi to divide a scene with objects at various levels as disclosed by Lathrop because objects can be quickly and efficiently located for ray intersection.

29. Regarding claim 39, Wrigley discloses a ray casting processor for rendering dynamic three-dimensional scenes, the processor comprising: a traversal unit, the traversal unit being coupled to a plurality of node caches for storing acceleration structure node data, the node data structured to improve accessibility according to ray coherence, the node caches arranged in an n-level hierarchy (Figure 6 and column 6, lines 35-67).

Wrigley does not clearly disclose a list unit, the list unit being coupled to a plurality of list caches for storing lists of object addresses for objects that have already been intersected by a ray, the list unit having a decision unit, the decision unit configured to prevent objects whose object addresses are stored in the list from being intersected again by the ray.

Munshi discloses a list unit, the list unit being coupled to a plurality of list caches for storing lists of object addresses for objects that have already been intersected by a ray (Figure 4), the list unit having a decision unit (Paragraph 0030, lines 1-7), the decision unit configured to prevent objects whose object addresses are stored in the list from being intersected again by the ray (Paragraph 0030, lines 7-23).

Therefore, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to modify Wrigley to monitor previous intersections of rays with objects as disclosed by Munshi because unnecessary calculations resulting from intersections by the ray are ignored (Paragraph 0027, lines 15-23).

Wrigley in view of Munshi does not clearly disclose a matrix loading unit, the matrix loading unit being coupled to a plurality of matrix caches for storing affine transformations in the form of matrices, the matrix caches arranged in an n-level hierarchy.

Lee discloses performing affine transformations using an affine transformation matrix (Paragraphs 0046 and 0047).

Therefore, it would have been obvious to a person of ordinary skill in the art at the time of the invention to modify Wrigley in view of Munshi to performing a

Art Unit: 2628

transformation using an affine matrix as disclosed by Lee because a simpler coordinate system can be obtained while preserving collinearity after the transformation

Wrigley in view of Munshi and further in view of Lee does not clearly disclose the list caches arranged in an n-level hierarchy.

Lathrop discloses the list caches arranged in an n-level hierarchy.

Therefore, it would have been obvious to a person of ordinary skill in the art at the time the invention was made to modify Wrigley in view of Munshi to divide a scene with objects at various levels as disclosed by Lathrop because objects can be quickly and efficiently located for ray intersection.

### ***Conclusion***

Any inquiry concerning this communication or earlier communications from the examiner should be directed to PHI HOANG whose telephone number is 571-270-3417. The examiner can normally be reached on Mon-Fri, 8:30am-5:00pm EST.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Xiao Wu can be reached on 571-272-7761. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Art Unit: 2628

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Phi Hoang/  
Examiner, Art Unit 2628  
February 12, 2011

/XIAO M. WU/  
Supervisory Patent Examiner, Art Unit 2628